In (4) the coefficient of $\sqrt{-1}$ may have any magnitude, and in (5) the coefficient of $\sqrt{-1}$ is the reciprocal of that magnitude. And since from any cubic (Theorem I.) (4) or (5) may be obtained, it follows, that, when the real part is unity, the coefficient of $\sqrt{-1}$ may be made less than unity, and real (Theorem II.).

Put n = coefficient of $\sqrt{-1}$, we have, by expansion,

$$(1+n)^{\frac{3}{4}} + (1-n)^{\frac{3}{4}} = 2-4\left(\frac{1}{3\,.\,6}\right)n^2 - 4\left(\frac{4\,.\,7}{3\,.\,6\,.\,9\,.\,12}\right)n^4 - 4\left(\frac{4\,.\,7\,.\,10\,.\,13}{3\,.\,6\,.\,9\,.\,12\,.\,15\,.\,18}\right)n^6, \text{ etc.}$$

The series, already converging, is made doubly converging by the high powers of n, since n has been made a fraction. Putting n, for example, no smaller than $\frac{1}{10}$, the correction for the sum of the series at the eighth term would be less than $\frac{1}{1{,}400{,}000{,}000{,}000{,}000{,}000}$. And, as the precision of the value of x is determined proportionally to the accuracy with which the series is summed, it follows that a good approximation to x may be obtained by using a very few first terms of the series.

A. M. SAWIN.

THE HABITS OF MURAENOPSIS TRIDACTYLUS IN CAPTIVITY; WITH OBSERVATIONS ON ITS ANATOMY.

THE Louisianian district of the Austroriparian region is a particularly rich field for the herpetologist. Thirty-six species of reptiles are known to be confined to its limits alone, not to mention a long list of others that range generally over the southern states; and to these we must add those species which are mentioned by the old French authors, but have not yet been taken by American naturalists, a knowledge of which fact always enhances the interest of a country in the eyes of the explorer, who pushes his way through its tangled jungles, or visits its unfrequented spots and its sultry forests, for the first time.

After my arrival in New Orleans, the months that are included in the pseudo-winter of this sub-tropical land came and passed by, before my collection could boast of a single specimen representing the Amphiumida: indeed, it was not until April had almost made its appearance that a superannuated old negro presented himself one morning with a live but rather small specimen of the three-toed siren, the subject of this essay.

He called it a 'Congo eel,' — a name which is indifferently applied by every one here, intelligent as well as ignorant, to both this reptile and Amphiuma means. Long before this, reports had come to me from far and near of the dreaded 'Congo,' or 'lamprey' as it is often called. It was universally said that its bite was invariably fatal. To such an extent was this believed, that, I am told, a physician of the city, of undoubted reputation in his profession, and a capital chemist, but possessing nothing more than a general knowledge of natural science, was actually making experiments with the view of examining the venom of this innocent amphibian. When my aims became pretty thoroughly known throughout my section of the country, I applied a very different kind of analysis to this problem: a good round sum of money was offered to any one who would bring me the full record of a well authenticated case of death from the bite of the Congo snake, or eel. It is almost needless to add, that I never had to pay the reward. One person, more mercenary than well informed in such matters, did bring forward a case of an hysterical old colored woman who had been bitten several years ago by a Congo eel, and died *six months* after the infliction of the wound, in spasms!

The small one, which now came into my possession, was placed in water, in a large comfortable vessel, for observations upon his habits, before he was finally consigned to his tank of alcohol. In handling him, he rarely

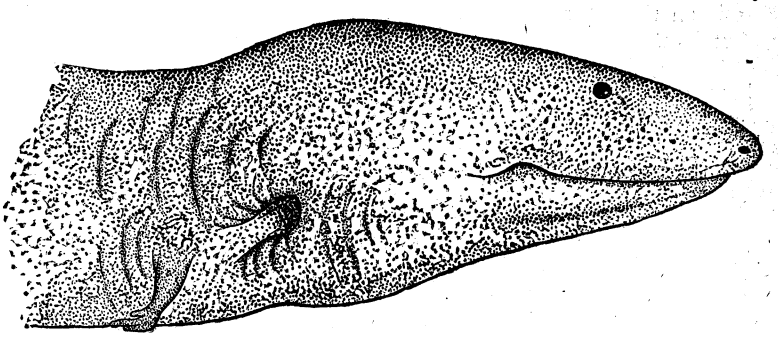

FIG. 1.—Life-size head of Muraenopsis tridactylus; adult. Drawn from the living specimen by the author.

offered to bite, unless the examination was prolonged or roughly conducted; then he would curl up, slowly open his mouth, and make an awkward longe at the fingers or hand that held him. Sometimes he would only open his mouth, and hiss in a subdued manner. On one occasion, however, this reptile succeeded in getting out of his tub during the night. When I found him, in the morning, in a distant part of the room, he snapped at me quite savagely several times before he was retaken. It was amusing to see the way in which he succeeded in leaping out of his place of confinement, — a large tin bath-tub, with the water seven or eight inches below the brim. He swam round and round with increasing rapidity till the necessary impetus was acquired, when he would prettily make a sort of spring over the side of his tub on the floor, where he would squirm round like an eel until he was replaced. In such situations he uses his legs to the full extent to which they seem capable of being put; in the water, too, these members are constantly brought into use, — the fore-pair when he desires to move very slowly forward, in which case he may or may not, generally not, use the hind-pair in aiding the action. The fore-pair are also used alternately to push himself one way or another, when he wishes to change his course. A common use for the hind-pair, is to throw them forward, and brace them against the ground he may be passing over, in order to check his onward movement either partially or entirely. In swimming about he has all the appearance of the common eel; and during these times he draws both pairs of limbs close beside his body, when his action is graceful and interesting to behold.

When these sirens are at rest, they either stretch out in gentle curves, sluggishly along the bottom, or, what is not very uncommon for them to do, curl up tightly, in a spiral manner, the latter two thirds of their length, while the head and remaining third is protruded forward in a direct line. In this curious position they float near the surface, the head being lowermost. If two occupy the same vessel, they often curl about each other in a rather affectionate manner; but I have never witnessed them quarrel or fight. One time I threw a dead king-snake into the tub of my first small specimen, the snake being at least three times as long as the siren. Imagine my surprise to see him fly at the intruder, seize him just below the head, straighten out as stiff as he could, then rapidly whirl round, as a drill does, causing the dead snake to be spirally coiled about his body. A moment of quietude followed this strange manoeuvre, during which time one could see a crunching movement on the part of the jaws of the siren going on; but, finding his enemy showed no resistance, he slowly let go his hold, and, freeing himself from the dead snake's coils, swam about the tub without paying him any further attention. In a few moments, however, I repeated the experiment, when he made the same attack with just as much vigor as before; but all subsequent trials failed, and I could never induce him to take further heed of such a harmless enemy.

This siren will eat crayfish in confinement; but I could never induce one to take any thing else, although raw meat is the commom bait used by the negroes in catching them for me. Sometimes before a meal, or may be after, your captive will swim gracefully about his limited quarters, and occasionally rise to the surface, stick his nose out of the water, and give vent to a loud blowing sound, that may be heard anywhere in a large room, even if conversation be going on. As remarked above, my collectors usually took such specimens as were brought me, with the ordinary hook and line, baited with fresh meat; but very often they are captured in hand dip-nets, or even thrown out of a shallow drain or bayou with a stick. They are most numerous after heavy rains, when their usual places of resort are flooded over. When taken by others than those who are collecting for me, they are invariably despatched on the spot, and dreadfully and wantonly mutilated, so deep-seated is the detestation and dread of this harmless creature in the minds of all the people hereabout.

In a large, shallow tank of water, I have before me now two fine living specimens of this siren, which have been under my observation for nearly a fortnight. The larger of these two has a total length of eighty centimetres, with a mid-girth of fourteen centimetres. I have kept specimens alive that measured a hundred or more centimetres, but they have since been consigned to alcohol. The specimen now before me, just measured, is of a dark olivaceous brown above, and entirely so on all the parts beyond the hind-pair of limbs. A patch of this color is also found upon the throat. The color of the under parts is a dull, whitish leaden hue, being mottled with an intermediate shade as it joins the darker and more sombre color of the dorsal aspect of the body. This mottling grows denser as it approaches the hinder limbs, where finally it merges into the general tint of the upper sur-

face, which is carried over the tail. A faint lateral crease is found along the mid-third of the body, with feeble corrugations crossing it vertically, that are quite evident as the creature writhes about, and the eel-like slime that naturally covers his entire body partially dries. The limbs are pretty well developed: each is three-fingered, or, better, each possesses three digits. The hinder limbs are larger than the fore ones, and stronger in every way. The body tapers to a tail beyond the genital fissure, but no well-marked constriction indicates to us its exact commencement, or attachment to the body. It is rounded beneath, and finished off along the median dorsal line with a thickened, feebly pronounced crest. Sections made through the body itself, between the fore and hind limbs, are elliptical, with the major axes in the horizontal plane. I have taken other measurements from this specimen, which I present in the form of a table.

Total length	80.0 cent.
Mid-girth	14.0 "
Length of fore-limb	1.7 "
" " hind-limb	2.5 "
" " head	6.5 "
Distance between the eyes	2.0 "
" " " nostrils	.6 "
" " mid-points bet'n eyes and nostrils,	2.2 "
Gill-cleft from eye	4.2 "
Fore-legs apart	3.1 "
Hind-legs "	2.2 "
Length of genital fissure	1.2 "
Commissure of jaw from gill-cleft	3.0 "
From a point midway between hind-limbs to tip of tail,	20.0 "

The nasal apertures are very small, and the eyes are black, round, a little more than a millimetre in diameter, and devoid of lids.

I may remark here, that, while engaged in taking these measurements, this specimen succeeded in seizing my thumb in his mouth, and immediately commenced his peculiar gyrations, turning himself in the long axis of his body; but I was too strong for him, and soon disengaged myself. The bite caused no more inconvenience than those I have received from alligators a month old.

The upper lips of the three-fingered siren are thin-edged and pendulous, extending from the commissure of the jaw to a point nearly opposite the nostril on either side, where they merge into the rounded snout. The lower lips do not meet in front by a centimetre. They are likewise thick and sharp-edged, overhanging the common integument of the lower jaw, and originating posteriorly within the commissure and beneath the upper lips. Minute glandular openings are seen on the head above, and in the maxillary space beneath, symmetrically arranged in rows, as on other parts of the body. We find the gill-clefts with two obliquely placed lips, with which they can be closed, the anterior one being the larger. The internal openings to the gill-clefts are far back in the pharynx, nearly opposite the rudimentary and partially cartilaginous larynx, which latter communicates directly with the superior extremities of the membranous pulmonary air-passages. A pair of normal lungs are among the most exquisite of structures in any vertebrate. Here they are particularly beautiful, being very long, cylindrical in form, extending far down into the abdomen, to terminate in pointed extremities. The right is thirteen centimetres longer than the left, and is carried nearly down to a point opposite the cloaca. From one end to the other, the alimentary tract is nearly or quite a straight tube. The oesophageal portion is rather small and tubular, with a few circular constrictions in its lower third. This division soon dilates into a spindle-shaped stomach of some size, which, in the specimen before me, is fourteen centimetres below the pharyngeal aperture. Below this last dilation the intestinal tract is carried straight to the cloaca, or rectal enlargement, into which the urinary and genital organs open. A very peculiar feature is noticeable in the circular constrictions that occur in the intestine at irregular intervals along its length. Very dark in color, the many-lobed liver is about twenty-six centimetres long, and covers at its lower tenth, or thicker extremity, an ellipsoidal gall-bladder of no small size. Many features of interest and importance present themselves in the circulatory and renal systems; but our space will not permit us to enter upon them here, as we have something to say about the osteology of Muraenopsis. Among other organs, a well-developed pancreas is to be observed; and the Wolffian bodies are present, and their dilated upper extremities are about opposite the lower end of the liver.

The tongue in this siren is in an extremely rudimentary stage of development. I will close this brief sketch of the anatomy of the soft parts — yet it can hardly be termed a sketch, for many structures have not even been alluded to — by calling the reader's attention to the remarkable length of time that nervous excitability, if I may apply such a term to the phenomenon, was kept up. My specimen was killed with chloroform. That of itself took a long time, forty minutes or more; but what is this, compared with the fact that its heart continued to pulsate in good rhythmical time during three hours and a half of my operations, and after the most extensive dis-

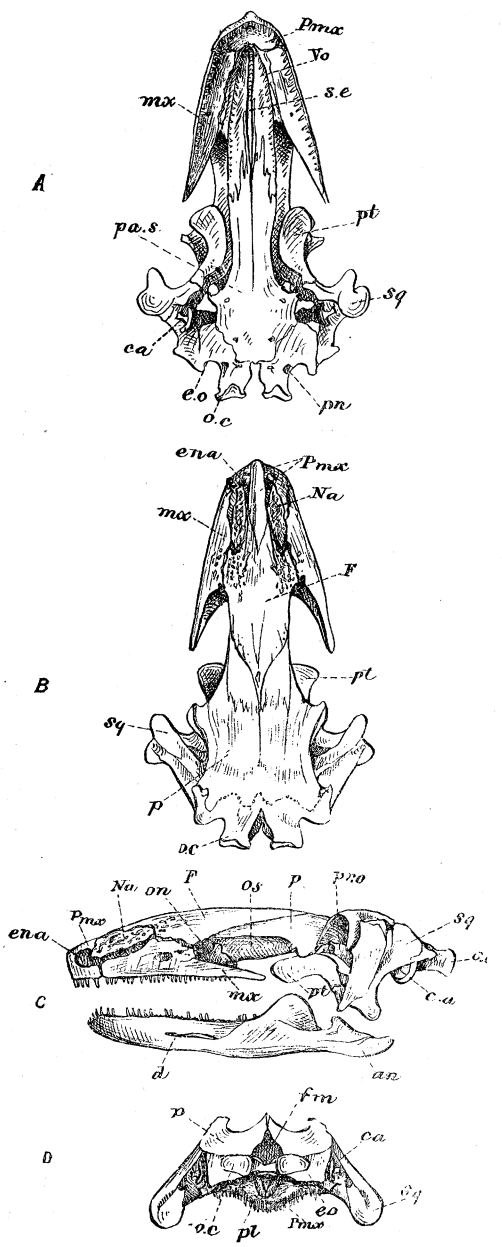

FIG. 2.—Dorsal, ventral, lateral, and posterior views of the skull of Muraenopsis tridactylus (life-size), respectively represented in A, B, C, and D, where like lettering has the same indication in each view. *Pmx*, premaxillary; *Vo*, vomer; *mx*, maxillary; *s.e*, splen-ethmoid; *pa.s*, parasphenoid; *pt*, pterygoid; *sq*, squamosal; *ca*, columella auris; *e.o*, exoccipital; *o.c*, occipital cordyle; *pn*, foramen for exit of pneumogastric and glosso-pharyngeal nerves; *ena*, external nasal aperture; *Na*, nasal; *F*, frontal; *p*, parietal; *on*, foramen for the passage of of the orbito-nasal nerve, the first division of the fifth pair, to the rhinal cavity; *os*, orbito-sphenoidal region; *pr.o*, pro-otic; *d*, dental element of mandible; *an*, angulae; *fm*, foramen magnum; *pl*, roof of the mouth.

sections had been made? And four hours and a half after, when all the organs had been removed, and inroads made upon the trunk, this creature would still writhe vigorously by simply pinching his tail, or close his jaws like a vice in a way that would put the hardiest of eels to shame, and crush any claim the latter might have in standing at the head of the list of those animals most tenacious of life. We find the cranium of Muraenopsis very thoroughly ossified, and many of the sutures observable only after close inspection. The teeth are of the pleurodont type, and may be seen in all stages of development in the deep grooves that exist in the mandible, the maxilla, the premaxilla (which usually supports twelve), and the entire inner margins of the descending plates of the vomers, which meet each other anteriorly (fig. 2, A). A long, slender, sphen-ethmoid is inserted between these last bones, quite distinctly seen on the inferior aspect.

The premaxilla throws backward a nasal process that overlaps the frontals above, and passes between the nasals. These latter segments are very much honeycombed and grooved, —a characteristic which is adopted by the anterior extremities of the frontals and the upper parts of the maxilla on either side. The coronal suture is seen beyond, a demi-lozenge shaped and elevated plate, developed by the united frontals, directed backward (fig. 2, B). Each outer margin of the parietal region is raised into a curling crest, as if pushed up by the unusually large squamosals, which lend to the lateral aspect of the skull of this creature such a massive appearance. As in other Urodela, a large columella auris is seen on either side, external to the extensive processes that project backward, to bear the occipital condyles (fig. 2, D). A pro-otic is well developed; but it is difficult to determine in the adult cranium whether a separate epi-otic and opisthotic exist or not, though I am strongly inclined to think they do not. The pterygoids are completely ossified, and quite extensive, horizontally flattened, and curved plates of bone, their anterior extremities being prolonged with a fibrous tissue to form the floors of the orbits. The lower maxilla is very deep and solid; and, although the meeting of the dentary elements anteriorly is quite extensive, the symphysis is not firm. Nearly the entire basicranial region is occupied by the wide-spreading and anteriorly produced parasphenoid (fig. 2, A), which, with its serrated margin, articulates with the parallel vomerine plates beyond.

We have presented us for examination in

the hyoidean apparatus (fig. 3) two reniform hypo-hyals in cartilage, surmounted by a triple piece of the same material that occupies the usual site of the glosso-hyal. In the median line we have a thoroughly ossified basi-hyal; while curved bony cerato-hyals, with expanded cartilaginous anterior ends, are suspended from the hypo-hyals. Four branchial arches are represented; the first pair being long, curved bones, and the remaining ones cartilage. The gill-clefts open to the rear of the last pair on either side.

The spinal column of an adult Muraenopsis contains one hundred and ten well-ossified vertebrae. The second and third of these have suspended from their transverse processes free ribs, of which the anterior pair is the larger. A strongly marked intercondyloid process is formed between the two concave facets on the anterior aspect of the atlas. As a rule, all these vertebrae, except the first and the extremely rudimentary caudal ones, are of the amphicoelous type, with lofty neural spines,—far-spreading transversed processes that become horizontally broadened in mid-spinal region,—and with well-marked zygapophysial processes to link the series together. None of these vertebrae are modified to form a sacrum in connection with the pelvis in the precaudal region; beyond which, each segment throws down parial hypapophysial processes, which are not lost, as we proceed backwards, until we arrive at the ultimate nodules that complete the tip of the tail.

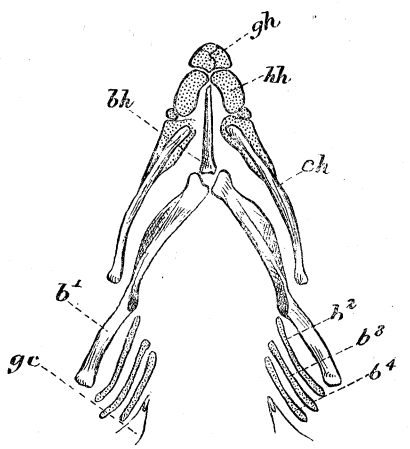

FIG. 3.—Hyoidean and branchial apparatus of Muraenopsis tridactylus; life-size; dotted parts in cartilage; *gh*, rudimentary glosso-hyal; *hh*, hypo-hyal; *ch*, cerato-hyal; b^1, b^2, b^3, and b^4, branchial arches; *gc*, gill-cleft.

In my specimen the thirty-third and thirty-fourth vertebrae have coalesced in the most remarkable manner, forming one bone, with nearly all the parts double. The appendicular skeleton is represented by extremely rudimentary shoulder and pelvic girdles, supporting equally feebly developed limbs, with their segments arranged as seen in fig. 4. We find

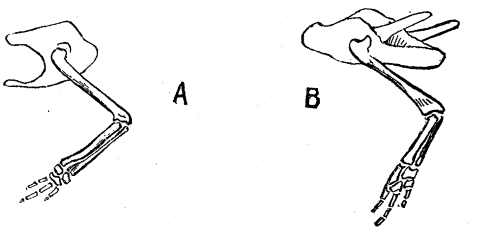

FIG. 4.—A, right fore-limb and rudimentary shoulder-girdle; B, right hind-limb and rudimentary pelvis, both slightly enlarged, of M. tridactylus. From dissections by the author.

the carpus has three cartilaginous elements in its structure,—two in the proximal row, and only one in the distal. This number is increased by an additional segment in the tarsus, which has two elements in each row, articulating with the digits, as shown in the figure.

Osseous tissue of an elementary character may be deposited in the humerus, the femur, and certain points in the pelvis, more particularly the projecting rod that appears to represent the pubic bone; otherwise all this part of the skeleton in our siren remains in cartilage throughout life. R. W. SHUFELDT.

THE GREAT TERMINAL MORAINE ACROSS PENNSYLVANIA.[1]

AFTER describing the investigations which elsewhere had demonstrated the existence of a true terminal moraine to the glacier covering north-eastern America, the author stated, that having obtained the aid of the geological survey of Pennsylvania, and, during a portion of his work, the assistance of Prof. G. F. Wright, he had been able to follow and define the southern limit of glaciation for the first time in a continuous line four hundred miles in length, and to find that it was everywhere marked by a remarkable accumulation of glaciated material, which, winding across mountains and valleys, from the lowlands of the Delaware to the great Alleghany plateau, was continuous from end to end, and formed a true terminal moraine.

There is a marked distinction between the glaciated portion of Pennsylvania and that region south of glacial action. Although the general topography of the two regions is alike, the varied superficial features due to glacial agencies, the far travelled and scratched bowlders, the smoothed and striated

[1] Abstract of a paper before the American association for the advancement of science, in Montreal, August, 1882. By Prof. H. CARVILL LEWIS.